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NUTRITIONAL QUALITY AND FOOD SAFETY EVALUATION OF DANGKE: THE ROLE OF COAGULANTS AND PRODUCTION HYGIENE PRACTICES

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Abstract
Background: Traditional dangke production in Cendana District lacks optimal hygiene and sanitation practices, creating a potential risk for microbial contamination. This study aimed to evaluate the nutritional content, microbiological safety, and hygiene and sanitation practices associated with dangke production in Cendana District. **Method:** The study analyzed a control dangke sample (produced by the researchers using lime juice as a coagulant) alongside a commercial dangke sample (produced by a local maker using papaya sap as a coagulant). This comparative experimental study, employing a descriptive approach, utilized a single sample for each type of coagulant. **Result:** Laboratory analysis revealed that the control dangke (lime-coagulated) possessed a denser nutritional profile, containing 14.07% protein, 13.32% fat, 4.70% carbohydrates, and 613 µg/100g of vitamin A. In contrast, the commercial dangke (papaya sap-coagulated) exhibited lower protein content (8.239%) and showed heavy contamination with Escherichia coli (>2400 MPN/g, failing to meet SNI 7388:2009 standards), although it tested negative for Salmonella. Sanitation observations indicated that the producer implemented only 32% (8 out of 25) of the standard hygiene and sanitation practices. **Conclusion:** while lime juice coagulation yielded optimal nutritional composition in the researchers' test samples, the commercial papaya sap-coagulated dangke from Cendana District posed a high risk regarding microbiological safety. These findings are specific to the samples tested in Cendana District and cannot be generalized to represent all dangke products in Enrekang Regency.

Introduction

Indonesia is a country with abundant biological and cultural diversity, a fact reflected in the richness of its traditional foods. Traditional foods serve not only as a source of nutrition but also play a vital role in the social, cultural, and economic lives of local communities (1). One such traditional food of iconic status is dangke from Enrekang Regency, South Sulawesi. Dangke is a cheese-like dairy product traditionally made from fresh cow's milk. Its unique

production process which commercially employs papaya sap as a natural coagulating enzyme imparts a distinctive flavor and texture that sets it apart from modern processed cheeses (2). Dangke production in Enrekang Regency is largely concentrated in Cendana District, the primary production hub, as the majority of the local population raises dairy cows and produces dangke using traditional methods on a home-industry scale (3).

The coagulation of milk casein during dangke production generally occurs via two main pathways: enzymatic coagulation using natural proteolytic enzymes and acid coagulation using organic acids. The fundamental differences between these two coagulation mechanisms directly influence protein retention and the physicochemical characteristics of the final dangke product. Acid coagulation such as that achieved using citric acid-rich key limes works by lowering the milk's pH to the casein isoelectric point without causing excessive protein hydrolysis. This mechanism results in a dense casein network, more effective whey expulsion, and lower product moisture content; consequently, the protein structure remains intact, allowing for higher protein levels and a denser texture in the final product (4,5). In contrast, enzymatic coagulation using papaya sap utilizes papain, a proteolytic enzyme. Papain not only coagulates casein but also actively hydrolyzes a portion of the protein into short-chain peptides that are soluble and lost along with the whey. This proteolytic activity results in a lower protein content in dangke made with papaya sap, yet produces a curd with a higher water-binding capacity, thereby yielding a final product with a softer and more elastic texture (6,7).

Despite its high nutritional potential and unique flavor profile, the processing of dangke which remains rudimentary and lacks consistent application of food hygiene and sanitation principles can negatively impact product safety (8). Raw dangke processed without strict sanitary oversight carries a high risk of contamination by harmful microbes such as Escherichia coli and Salmonella. Such microbial contamination can stem from the quality of washing water, the hygiene of processing personnel, and the condition of the porous coconut-shell molds used for shaping (9,10). Therefore, this study aims to comprehensively evaluate the nutritional quality and safety of dangke in Cendana District, Enrekang Regency. Specifically, the research compares the nutritional composition of dangke produced using key lime coagulant (control) against that produced using papaya sap coagulant (commercial), assesses the microbiological safety of commercial products, and evaluates adherence to hygiene and sanitation practices in traditional production units, with the goal of providing concrete, science-based recommendations to enhance the quality and safety of this local food product (11,12).

MATERIALS AND METHODS

This study is a laboratory-based experiment employing a quantitative descriptive approach, complemented by qualitative observations regarding hygiene and sanitation

aspects of the traditional dangke production process. The research was conducted in May 2026 in Cendana District, Enrekang Regency. The study location was selected purposively, based on the fact that Cendana District is one of the major dangke production hubs and has the highest number of household-scale producers in Enrekang Regency. Laboratory analysis of the nutritional content and microbiological contamination of the samples was performed at the Laboratory of the Center for Standardization and Industrial Services for Plantation Products, Metal Minerals, and Maritime (BBSPJIHPMM).

The samples used in this study consisted of two types of dangke made from fresh cow's milk using different coagulants: lime juice (prepared by the researcher as a control) and papaya sap (obtained as a commercial sample from a producer). The sample size was limited to one unit per coagulant type due to technical constraints in the field and funding limitations. The lime-coagulated dangke was produced by the researcher (control) under hygienic conditions and was intended solely for the analysis of macro- and micronutrient content. Microbiological testing was not performed on the lime-coagulated control sample due to the inability to guarantee sterility against environmental exposure; consequently, no conclusions regarding its microbiological safety profile could be drawn. Meanwhile, the papaya sap-coagulated dangke was obtained directly from a local producer in Cendana District and was analyzed for both nutritional content and microbiological safety. Due to the limited sample size and the absence of test replication (such as triplicates or duplicates) for laboratory parameters, the data are presented using descriptive quantitative analysis as single absolute values, without mean values or standard deviations (SD). The findings of this study are specific to the samples tested in Cendana District and cannot be generalized to represent all dangke products in Enrekang Regency.

Macronutrient quality testing included protein content analyzed via the Kjeldahl method (AOAC 928.08), fat content using the Soxhlet extraction method (AOAC 960.39), moisture content, and carbohydrate content calculated using the "carbohydrate by difference" method. Vitamin A (a micronutrient) was analyzed spectrophotometrically using a UV-Vis spectrophotometer (Shimadzu UV-1800) at the wavelength of maximum absorbance. Microbiological safety evaluation was conducted based on contamination parameters for the indicator bacterium Escherichia coli and the pathogen Salmonella. E. coli testing was performed using the Most Probable Number (MPN) method in accordance with SNI 2897:2008 standards, while qualitative analysis for Salmonella employed isolation and biochemical identification methods following SNI ISO 6579:2015. Acceptable limits for microbial contamination were referenced against the national standard SNI 7388:2009 regarding maximum limits for microbial contamination in food.

The application of hygiene and sanitation practices during the dangke production process was assessed through direct observation using a checklist questionnaire based on the Regulation of the Minister of Health of the Republic of Indonesia Number

1096/Menkes/Per/VI/2011 concerning Food Service Hygiene and Sanitation, as well as the Good Manufacturing Practices (GMP) guidelines from the Indonesian Food and Drug Authority (BPOM). The observation sheet covered 25 critical assessment criteria grouped into three main pillars: food handler hygiene, production equipment sanitation, and the hygiene of the food processing environment and facilities.

The observational data were analyzed and presented as hygiene and sanitation compliance percentages to determine the extent to which local producers adhere to good food production standards. This study is limited to the analysis of the nutritional quality of dangke produced in Cendana District using key lime as a coagulant, and the analysis of the microbiological safety of dangke produced using papaya as a coagulant. Microbiological testing was not performed on the key lime dangke, and nutritional quality analysis was not conducted on the papaya dangke. Furthermore, this study did not analyze the fresh milk used as the primary raw material.

Results

The nutritional quality of dangke was analyzed based on macronutrient composition (protein, fat, and carbohydrates) and a micronutrient parameter, specifically Vitamin A content. As a control, dangke prepared by the researchers using lime juice as a coagulant was analyzed for its nutritional content to allow for comparison with commercial dangke produced using papaya sap as a coagulant. The results of the laboratory analysis regarding the nutritional composition of the control dangke (lime-coagulated) are presented in Table 1.

Table 1 Nutritional content of dangke (key lime coagulant) per 100 g

Parameter	Result
Protein (%)	14.07
Carbohydrate (%)	4.70
Vitamin A (µg)	613
Fat (%)	13.32

Based on Table 1, laboratory analysis reveals that the control dangke sample—prepared using lime juice as a coagulant—possesses a dense macronutrient profile, with protein, fat, and carbohydrate contents of 14.07%, 13.32%, and 4.70%, respectively. Additionally, the Vitamin A content was recorded at 613 µg RE/100g. For comparison, laboratory analysis of commercial dangke produced using papaya sap in Cendana District showed lower protein levels (8.239%), alongside a moisture content of 66.005% and an ash content of 0.934%.

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Table 2 Microbiological analysis of dangke using papaya coagulant.

Parameter	Result	SNI 7388:2009	Status
E. coli (MPN/g)	>2400	Max. 3	Does not meet the requirements
Salmonella (/25g)	Negative	Negative	Qualify

Based on the microbiological test results in Table 2, the commercial dangke sample (produced using papaya sap) from Cendana District was found to have an extremely high level of Escherichia coli contamination, exceeding the laboratory instrument's upper detection limit of >2400 MPN/g. These results indicate that the commercial product fails to meet consumption safety requirements under SNI 7388:2009 standards, which set a maximum E. coli contamination limit of 3 MPN/g. Conversely, testing for the pathogen Salmonella yielded negative results per 25-gram sample, thereby complying with national safety standards.

A qualitative evaluation of the dangke production chain's hygiene was conducted through direct observation using a checklist comprising 25 critical assessment criteria, based on Indonesian Ministry of Health Regulation No. 1096/2011 and BPOM guidelines on Good Processed Food Production Practices (CPPOB). To facilitate data verification, Table 3 presents the detailed assessment results, including total scores and compliance percentages for each assessment sub-category.

Table 3 Hygiene and sanitation practices of dangke vendors

Hygiene and Sanitation Observation Aspects	Yes	No	Compliance (%)/Total
Personal Hygiene			
Hands washed before and after food preparation?		V	0
Food handlers wearing aprons, hairnets, and gloves?		V	0
Clean clothing worn during food preparation?	V		100%
Fingernails kept short and clean?	V		100%
Face masks worn during food preparation?		V	0
TOTAL	**2**	**3**	**40% (2/5)**
B. Equipment Cleanliness			
Utensils washed before and after use?		V	0,0%
Utensils dried after washing?		V	0
Utensils stored in a covered area?		V	0
Separate utensils used for raw and cooked ingredients?		V	0

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Designated storage area for utensils available?	V		100%
EQUIPMENT CLEANLINESS SUB-TOTAL	**1**	**4**	**20% (1 / 5)**
C. Food Processing			
Ingredients washed before preparation?	V		100%
Food cooked thoroughly?		V	0
Preparation process carried out hygienically?		V	0
Ingredient quality checked before use?		V	0
Food additives (coagulants, preservatives, colorings, etc.) used according to regulations?	V		100%
TOTAL	**2**	**3**	**40% (2 / 5)**
D. Food Storage			
Food stored in covered containers?	V		100%
Food stored at safe/appropriate temperatures?	V		100%
Raw and cooked ingredients kept separate?		V	0
Expiration dates checked?		V	0
Serving area clean and free from dust and insects?		V	0
TOTAL	**2**	**3**	**40% (2 / 5)**
E. Processing Environment			
Preparation area clean?		V	0
Covered trash bins available?	V		100%
Environment free from insects/animals?		V	0
Water used free from contamination?		V	0
Liquid waste drained into the proper channels?		V	0
TOTAL	**1**	**4**	**20% (1 / 5)**
OVERALL COMPLIANCE TOTAL	**8**	**17**	**32% (8 / 25)**

Based on the data summary in Table 3, traditional dangke producers in Cendana District have implemented only 8 (32%) of the 25 hygiene and sanitation criteria parameters observed. Conversely, 17 aspects (68%) remain unfulfilled by the producers. This low level of compliance is primarily driven by the "Equipment Cleanliness" and "Processing Environment Hygiene" sub-categories, each of which achieved a compliance rate of only 20.0%. Compliance rates for Personal Hygiene, Processing, and Food Storage stood at 40.0%. These objective descriptive findings indicate a low level of adherence to hygienic food production standards at the production sites.

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DISCUSSION

Based on the macronutrient analysis, the control dangke produced using lime juice as a coagulant exhibited a protein content of 14.07%, a fat content of 13.32%, and a carbohydrate content of 4.70%. In contrast, the commercial dangke produced by a local manufacturer using papaya sap as a coagulant showed a protein content of 8.239%. These differences in macronutrient values are likely linked to the distinct coagulation mechanisms involved. The addition of lime juice rich in citric acid lowers the milk's pH to the casein isoelectric point without triggering further protein degradation; this results in a denser protein curd and higher protein retention. Conversely, papaya sap contains the enzyme papain, which is actively proteolytic; this enzyme cleaves casein peptide bonds into smaller, water-soluble protein fragments, causing some protein to be lost in the whey and resulting in a lower final protein content in the dangke (13). However, this difference in protein content should be interpreted cautiously as a trend observed in the specific samples tested, rather than as proof of absolute superiority. Since the laboratory analysis was conducted on single samples without replication or statistical significance testing, conclusions regarding coagulant effectiveness are limited to the researcher's experimental samples and cannot be generalized to all dangke products beyond those tested.

In addition to macronutrient content, the micronutrient profile of the control dangke (coagulated with lime juice) was analyzed, revealing a Vitamin A content of 613 µg RE/100g (14). The unit for Vitamin A was standardized as Retinol Equivalent (RE) throughout the manuscript to align with national nutritional standards; this conversion value is derived by adjusting for the biological activity of carotenoid compounds within the body. This Vitamin A level indicates the potential of lime-coagulated dangke as a local food-based source of micronutrients to help meet the population's daily nutritional needs (15). However, to comparatively confirm the significance of this micronutrient content, future research should analyze the Vitamin A levels of papaya sap-coagulated dangke using the same spectrophotometric method, incorporating sufficient sample replication to enable valid bivariate statistical testing and demonstrate differences in nutritional quality between the two types of dangke.

The high level of Escherichia coli contamination (>2400 MPN/g) in commercial dangke samples produced using papaya sap coagulant indicates a significant microbiological safety risk and a failure to meet SNI 7388:2009 standards. These findings correlate with the poor hygiene and sanitation practices of local producers in Cendana District, who met only 8 (32%) of the 25 assessment criteria . Analysis of the production chain identifies the primary critical point for this fecal contamination as cross-contamination resulting from the use of traditional coconut shell molds. Coconut shells are porous, hollow organic materials that absorb water and easily retain milk protein residues from previous production cycles (16). When these shells are washed without adequate drying and sanitization, the moisture within

their porous structure creates an ideal breeding ground for microbial growth. Direct contact between these unsterilized molds and the warm dangke curd during the molding process facilitates the direct transfer of bacteria into the final product.

In addition to the molds used, this microbiological contamination is exacerbated by the poor quality of the processing water source and the surrounding environmental sanitation. Producers are known to use untreated well water without prior heating or disinfection to wash production equipment and dangke molds. The well water in the area is highly susceptible to coliform bacteria infiltration because the cow milking facilities are located very close to livestock waste drainage channels. These unhygienic environmental conditions facilitate airborne bacterial transmission, as dried livestock feces can be carried by the wind and contaminate fresh milk during the milking process. This fecal-oral contamination pathway is further compounded by the processors' poor personal hygiene such as failing to wash hands with soap before handling food, not wearing aprons or masks, and using banana leaves for wrapping that have not been properly sanitized. It is the combination of all these factors that causes E. coli levels to exceed safety limits for consumption, posing a significant health risk to consumers if the dangke is eaten directly without adequate reheating (17).

Conclusion

Based on the analysis of the tested samples, the use of lime juice as a coagulant for dangke produced by the researchers under controlled conditions yielded an optimal nutritional profile regarding proximate composition and Vitamin A content (protein 14.07%, fat 13.32%, carbohydrate 4.70%, and Vitamin A 613 µg RE/100g). As a result, this lime-coagulated dangke holds significant potential as an alternative source of animal protein and micronutrients for the public. In contrast, commercial dangke samples coagulated with papaya sap, obtained from local producers in Cendana District, failed to meet the consumption safety standards set by SNI 7388:2009 due to high levels of Escherichia coli*contamination (>2400 MPN/g). This high level of microbiological contamination in commercial dangke is likely linked to inconsistent application of hygiene and sanitation principles throughout the production chain in Cendana District specifically, milking locations situated near sources of contamination and unhygienic handling of traditional coconut-shell molds. It must be emphasized that the high nutritional quality observed in the lime-coagulated dangke in this study was achieved under sterile production conditions maintained by the researchers; furthermore, the findings regarding microbiological safety are specific to the samples tested in Cendana District and cannot be generalized to represent all dangke products in Enrekang Regency.

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